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Skeletal Biology of Apurguan: A Precontact Chamorro Site on Guam

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ABSTRACT The human skeletal remains of a minimum of 152 individuals from the precontact Latte Period (AD 1000–1521) on Guam, Mariana Islands, are described. The sample, recovered at Apurguan, in the Tamuning District, is one of the largest series of well-provenienced Chamorro skeletal remains to be analyzed in recent years. The size and systematic nature of this database are a major contribution to the human biology of the region. Paleodemographic characteristics, dental and skeletal morphology, and paleopathology are presented, along with a limited examination of sex differences in frequencies of nonmetric variation.

The mortuary sample, consisting of 51 subadults and 101 adults, exhibits underrepresentation of females, highest subadult mortality between 2 and 10 years, and an adult average age-at-death of 43.5 years. Cranial and infracranial indices and nonmetric variation are consistent with the Chamorro's Southeast Asian origins. There are few statistically significant sex differences in nonmetric variation which suggests close genetic affinity. The frequency of dental pathology overall is low, reflecting a well-balanced, varied diet, and consistent with preagricultural subsistence; however statistically significant sex differences suggest the influence of differential cultural behaviors or resource access.

Paleopathological observations include healed fractures (more common in males), little advanced osteoarthritis, evidence for gouty arthritis, and treponemal disease (yaws). One individual, a young adult male, was interred with 10 human bone spear points in situ. Twenty percent of the primary burials exhibit evidence of postdepositional removal of selected skeletal elements for cultural purposes such as keepsakes or raw material. Am J Phys Anthropol 104:291–313, 1997.

The prehistory of Micronesians has long been neglected in favor of the more captivating story of the peopling of Polynesia. Howells (1973a) called the physical anthropology of Micronesian people "deplorable," a situation which had improved to a "void" by 1987, the year of the first international symposium devoted only to Micronesian prehistory (Pietrusewsky, 1990a). Caused by a paucity of skeletal remains, which initially were "collections" rather than excavations, from a limited number of islands, and relatively poor preservation, the situation has only just begun to improve as a result of progressive urbanization and Cultural Resource Management (Hunter-Anderson and Butler, 1995). However, much of this improvement in knowledge has occurred only in the islands of western Micronesia, the Marianas

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in particular, where, until recently "any investigation yielding portions of more than 20 individuals is considered a major sample" (Hunter-Anderson and Butler, 1995:61). This paper provides a general descriptive summary of one of the largest skeletal series from Guam ever excavated. The emphasis of this paper will be on presentation and discussion of the paleodemography, the less utilized infracranial and deciduous dental data, contrasting data by sex, and observations of paleopathology in the Apurguan series. More detailed information, including comparisons of this series with other Mariana skeletal samples, may be found in the draft report (Pietrusewsky et al., 1992).

LITERATURE REVIEW

Since its recovery in 1922–23, the largest human skeletal series representing the Mariana Islands has been the "Hornbostel Collection" curated at the Bishop Museum in Honolulu (Pietrusewsky, 1971) and currently considered for repatriation and reburial. This collection of human remains from a variety of locations (e.g. Guam, Saipan, Tinian) was utilized in early analyses of Chamorro dentition (Leigh, 1929) and skull nonmetric variation (Wood-Jones, 1931), and has been more intensively documented by a team of researchers from Japan (Hanihara, 1986, 1993; Suzuki, 1986; Dodo, 1986; Ishida, 1993; Koizumi, 1986). More recently, the collection has provided skull metric and nonmetric data for multivariate analyses of relationships in the Pacific and Asia (e.g., Brace et al., 1990; Howells, 1989, 1990; Pietrusewsky, 1990b,c, 1994; Turner, 1990). These studies suggest biological affiliation of the Chamorro with other Micronesian populations, distinct from Polynesians, and deriving from peoples of Island Southeast Asia, and Asia (Pietrusewsky, 1990c, 1994).

While the Hornbostel skeletal sample has essentially defined the prehistoroic inhabitants of the Mariana Islands up to the present time, the archaeology of the sites was never published, and reexamination of the field notes suggests the sample is biased in a number of ways (Graves, 1991). Hornbostel's emphasis was on mortuary remains associated with latte structures, megalithic pillars with hemispherical capstones arranged in parallel rows, thought to represent habitation or other buildings. Thus, only the region within and immediately around the extant latte structure was excavated, the sampling was done by burial rather than metric unit so missing other activity areas, and many of the less-well-preserved remains were not collected (Graves, 1991).

Much of the subsequent osteological research in this region has concentrated on archaeological contract work: typically comprising small, isolated samples, documented in hard-to-access "reports," and rarely published (see Hanson, this volume). In the past several years, however, three large scale archaeological excavations on Guam (Apurguan, Gongna-Gun Beach, and Hyatt) have recovered greater numbers of human skeletons, under controlled circumstances, and included complete recovery of all human bone present in the excavation area regardless of preservation. These latter series have been highlighted in recent studies (see Anderson, 1992; Rothschild and Heathcote, 1995; Stodder et al., 1992; Trembly, 1995, 1996) but, as with the Hornbostel collection, no detailed descriptive documentation of the remains is currently available. Thus, the present study represents one of the first comprehensive summaries of a large skeletal series from the Mariana Islands.

MATERIALS AND METHODS

Archaeological survey of 1.5 acres of a proposed waterfront development in Tamuning Municipality, Agana, Guam, Mariana Islands, revealed evidence of prehistoric occupation and mortuary activity. The locality is known to the Chamorro as "Apurguan," the site of a former Chamorro village (Fig. 1). The International Archaeological Research Institute, Inc. (IARII) (Honolulu, Hawai'i), excavated the village site and recovered the human remains in 1990. Osteological analysis was performed at the IARII laboratory in Honolulu by the authors from 1990 to 1991 (Pietrusewsky et al., 1992).

Radiocarbon dating of human bone from seven individual burials was conducted using the AMS method by Dr. Thomas Stafford of the University of Colorado at Boulder

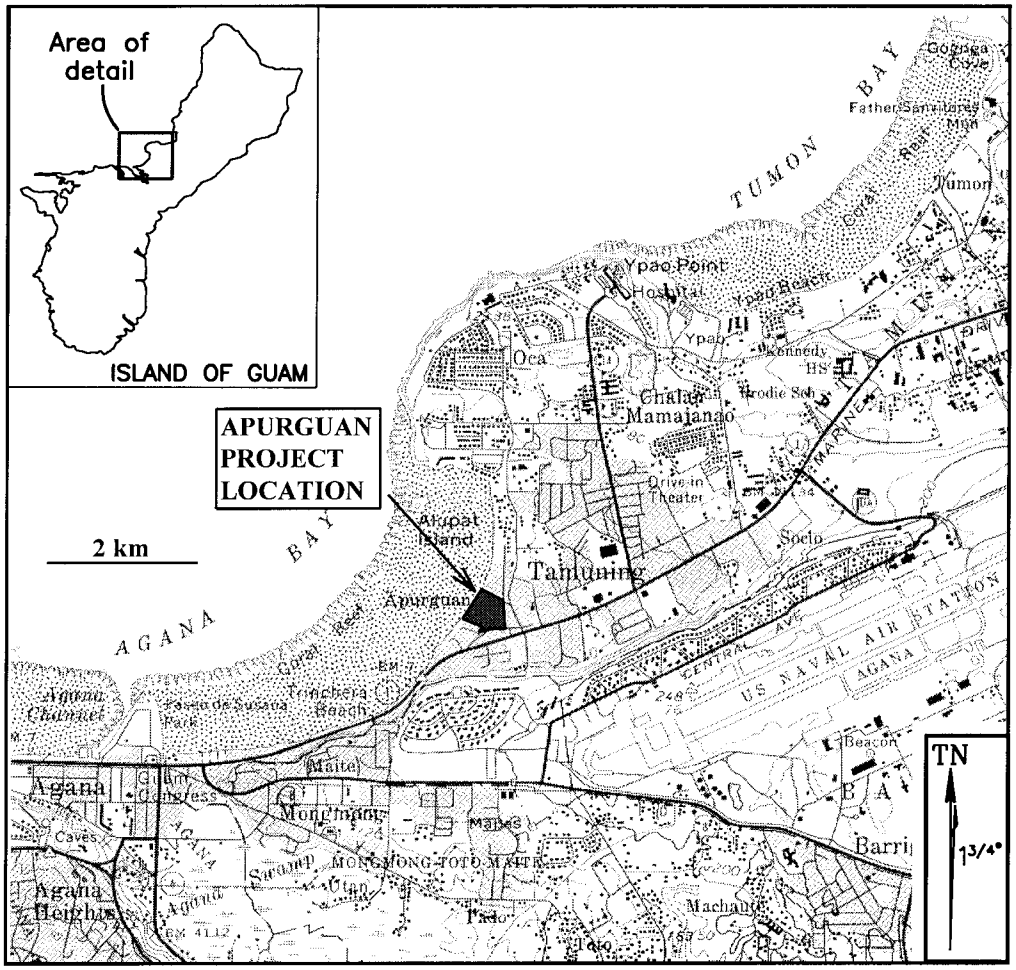

Fig. 1. Map locating the Apurguan site on Agana Bay, Guam (from USGS map of Guam compiled in 1977, edited 1978, scale 1:50,000).

Institute of Arctic and Alpine Research. The corrected dates (Stuiver and Reimer, 1993), with good collagen collection, range from AD 1046 to 1663 (1 σ). The provenience and artifact associations suggest these Chamorro remains date from the precontact Latte Period (AD 1000–1521). After examination and analysis, the skeletal remains were returned to Guam and reinterred in a concrete structure on the grounds of the project.

Standard osteometric methods were utilized during the analysis of the Apurguan skeletal material. Graphic and textual records of skeletal completeness, and descriptions of preservation, paleopathology and anomalies, were made for each individual burial. Sex was determined using cranial and pelvic morphology (e.g., Bass, 1987; Ubelaker, 1989), humeral and femoral head diameters (Krogman and İşcan, 1986), and other infracranial dimensions. Sex determinations were not attempted in subadults less than 15 years of age. Adult age-at-death was estimated using as many methods as possible, including ectocranial suture fusion (Meindl and Lovejoy, 1985), pubic symphysis morphology (Brooks and Suchey, 1990; Gilbert and McKern, 1973; Katz and Suchey, 1986; McKern and Stewart, 1957; Todd, 1920, 1921), auricular surface morphology

(Lovejoy et al., 1985), and sternal rib end changes (İşcan et al., 1984, 1985). In the absence of these specific indicators general observations of dental wear and osteoarthritis were made. In subadults, age-at-death was estimated using epiphyseal fusion, diaphyseal lengths and dental eruption criteria (Bass, 1987; Fazekas and Kósa, 1978; Krogman and İşcan, 1986; Ubelaker, 1987). Most of these criteria were developed using a wide spectrum of racial groups. Currently, there are no standards developed from known-age Micronesian skeletal populations.

Swiss-made sliding, spreading, and small coordinate calipers, digital dental calipers, metric tape measure, protractor, and an osteometric board were utilized to record standard measurements in the cranium, mandible, teeth and infracranial skeleton (e.g. Brothwell, 1981; Brown, 1982; Howells, 1973b, 1989; Martin, 1957; Moore-Jansen and Jantz, 1986; Olivier, 1969; Wood-Jones, 1929). All indices reported here are calculated from the mean measurements to mitigate the effects of small sample size. Adult stature was estimated on complete long limb bones using regression formulae generated from New Zealand Maori (Houghton et al., 1975).

Epigenetic (nonmetric) variation was documented in the cranium, mandible, dentition, and infracranial skeleton (Pietrusewsky, 1969, 1976; Anderson, 1964; Brothwell, 1981; De Villiers, 1968; El-Najjar and McWilliams, 1978; Hauser and De Stefano, 1989; Pardoe, 1984; Saunders, 1978). Dentitions were systematically observed for tooth presence, enamel hypoplasia, caries, abscesses and attrition, in addition to three indicators of periodontal disease: calculus, alveolar resorption and rolled rim, and betel-nut staining in adults (Lukacs, 1989). Osteoarthritis was systematically scored in the major joints of the appendicular skeleton and the vertebrae were evaluated for degenerative changes to the centra and facets (Brothwell, 1981). Other examples of pathologic change, such as evidence of infection, trauma, circulatory disturbance, metabolic disease, congenital variation, tumors, and cultural alterations (İşcan and Kennedy, 1989; Ortner and Putschar, 1981; Steinbock, 1976; Zimmerman and Kelley, 1982) were noted and described in detail.

Data were analyzed using the SAS statistical software (SAS Institute, 1988). Sex differences in the skull, infracranial, and dental nonmetric traits and pathology were tested using 2×2 contingency tables and applying the chi-square (χ^2), continuity adjusted chi-square (χ^2_c), or the Fisher's Exact Test statistics following Thomas (1986). Statistical significance is shown at $\alpha = 0.10$ and 0.05.

Skeletal preservation and taphonomy

One hundred ten of the 152 burials recovered from Apurguan include both skull and infracranial elements, while the remaining individuals are represented by either infracranial remains alone (19.1%) or only skull fragments (7.9%). Skeletons missing only a few bones (substantially complete) are rare (7.9%) in this series. Most of the individuals are represented by more than half of the bones of the skeleton (67.1%) and 15.8% have less than half of the skeletal elements present.

Approximately one-third of the skeletons had good or good to fair bone preservation, with fair bone preservation in 40.8%. In general, the cancellous bone of the skeleton, such as the epiphyseal ends of the long bones, the vertebral bodies, and the iliac blade and pubis of the os coxae, was lost to crushing or weathering. The dense cortical bone of the long limb diaphyses, carpals, tarsals, and vertebral arches was intact or could be reconstructed. Skeletal completeness and preservation were affected by prehistoric disturbance and removal of skeletal elements for cultural purposes, either before or after skeletonization (Hanson, 1990), disturbance indicated by pit features, continuous use of the village area, soil type, the tropical environment, the activity of tree roots, crabs, insects and other animals; and the weight of overlying structures which often resulted in complete crushing of the bone.

RESULTS

The Apurguan sample

Of the 152 individuals recovered at Apurguan, 66.4% (101/152) of the burials are

TABLE 1. Age and sex distribution in the Apurguan, Guam skeletal series

Age category	Males	Females	?Sex	Total
Fetal	—	—	5	5
Newborn–0.9	—	—	7	7
1–1.9	—	—	—	—
2–4.9	—	—	14	14
5–9.9	—	—	13	13
10–14.9	1	—	4	5
15–19.9	5	2	—	7
20–24.9	4	1	—	5
25–29.9	10	2	1	13
30–34.9	7	3	—	10
35–39.9	4	5	—	9
40–44.9	3	2	—	5
45–49.9	4	4	—	8
50+	4	8	1	13
Adult	5	4	2	11
Young adult	4	6	—	10
Middle aged	6	8	1	15
Middle–old aged	2	—	—	2
Total	59	45	48	152

adults (Table 1). Because of less than perfect preservation, 38 adults were assigned to broad age categories: adult, young adult, middle-aged, or old-aged. Five percent (5/101) of the adults could not be sexed. Adult males (53) outnumber adult females (43), yielding a sex ratio of 123:100. This underrepresentation may result from differential burial practices, such as the recent discovery of an overrepresentation of young adult females in an inland site (Hunter-Anderson, 1995). Female deaths appear to be evenly distributed over the adult age ranges, with a slight peak at ages 35–39, perhaps reflecting child-bearing mortality, as the range of age at first birth in late 19th century Guamanians was 16–30 years (mean 22.5 years) (Underwood, 1990). Of the 36 adult males assigned a specific age estimate, a peak in the number of deaths occurs in the 25–30 year age interval (27.8%), followed by the 30–35 year age interval. The much higher number of deaths in these particular age intervals may be attributed to risky activity undertaken by young men, including warfare and accident. Unlike Apurguan females (18.6%), fewer males (11.1%) reached 50 years of age.

Fifty-one subadults (less than 20 years of age), including five fetuses, comprise the remaining third of the Apurguan skeletal sample. This proportion of subadults falls within the range (30% to 70%) expected for a cemetery population (Weiss, 1973). Of the 51 subadults in the Apurguan sample, 23.5% are between 5 lunar months and 1 year of age. Most of the subadult deaths occurred in the 2 to 5 year age interval (27.5%) and the 5 to 10 year age interval (26%), and may be attributed to nutritional, parasitic and/or disease stress.

In order to mitigate the effects of mortality biases (e.g. environmental, cultural and archaeological) and methods biases (e.g. underaging of adults), emphasis may be placed on fertility estimators and the subadult component of the skeletal sample (Jackes, 1992; Saunders and Hoppa, 1993). Using an abridged life table which consolidates all individuals over the age of 25 into one large age interval, the Juvenile-Adult ratio ($D_{5–14.9}/D_{20+}$) is calculated as 18/101 or 0.178, while Mean Childhood Mortality (MCM), found by averaging the ${}_5q_5$, ${}_5q_{10}$, ${}_5q_{15}$, (0.103 + 0.044 + 0.065/3), is 0.071 (Jackes, 1992, 1994). Graphing these two values together with historical and archaeological life table data (Jackes, 1992), the Apurguan population falls within the region of slowly increasing populations (Fig. 2), suggesting that the sample is relatively unbiased. Fertility in the Apurguan sample is estimated as five children, using the MCM:JA plotted with fertility in model and historical data (Jackes, 1994). Another negatively correlated estimator of fertility is the D20+/D5+ statistic (Konigsberg et al., 1989), which in this sample is 101/126, or 0.80.

Skull morphology

Cranial shape in both sexes (32 males and 27 females) falls in the lower range of mesocranic bordering on dolichouranic, or more long-shaped cranial vaults (76.9 in males, 75.1 female). Cranial vault heights, measured as a proportion of either length or breadth, correspond with other Chamorro crania in being typically high in both males and females. Small sample size precludes interpretation of female facial proportions and nasal shape. There is no maxillary projection or prognathism in the male crania (gnathic index 91.8), and the upper and total facial indices are of medium proportions. Male nasal openings are typically narrow (leptorrhine). The shapes of the eye

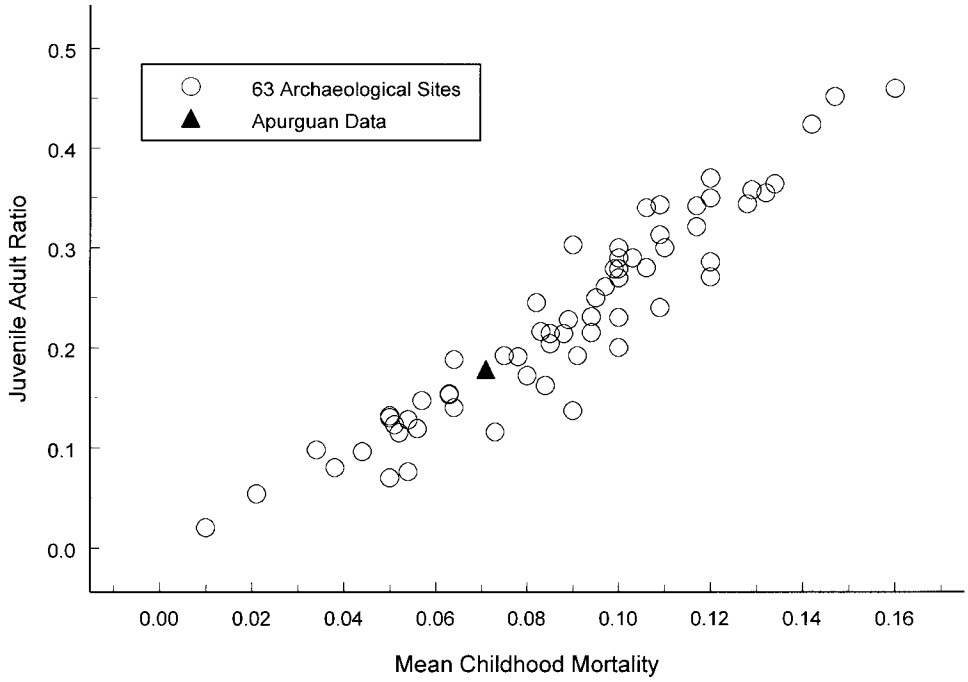

Fig. 2. Apurguan data on a plot of JA Ratio against MCM in 63 archaeological samples (after Jackes, 1992).

orbits in males and females are mesoseme or medium. In both sexes, the palate is brachyurane, or broad (maxillo-alveolar indices: 117.4 and 122.3). The cranial module, providing a crude indication of vault size, is 156.2 in Apurguan males and 148.7 in females. Cranial capacity, estimated using the Lee-Pearson formulae (Olivier, 1969) is 1,513.8 cc (medium capacity) in males and 1,310.9 cc (submedium capacity) in females.

The mandibular index, expressing the length of the mandible as a proportion of its breadth, is broad (83.5) in males and medium (86.1) in females. The degree of divergence of the ascending ramus from the mandibular angle (gonio-condylar index) is 86.2 in males and 84.3 in females. The ramus index, which measures the relative breadth of the ascending ramus, is 61.5 (medium) in males and 63.7 (medium to high) in females. The general robusticity of the mandibular body, measured at the level of the mental foramen, is identical in males (43.3) and females (43.4).

Skull nonmetric variation. Nonmetric variation scored in the Apurguan skulls is summarized in Table 2. There is more variation in the supraorbital structure in males than in females, but overall, the presence of a single notch is most common (65.3%). A double infraorbital foramen, the route of the infraorbital vessels and nerve to the face, occurs only in male maxilla (16.7%). The absence of zygofacial foramina is slightly heritable (Hauser and De Stefano, 1989), occurring equally in males and females in this series. *Os japonicum*, maxillary torus and an abnormal ovale-spinosum are not found in this series. A bridged anterior condylar, or hypoglossal canal, morphology is slightly more common in males than females. The posterior condylar canal, for transmission of an emissary vein to the sigmoid sinus, is absent (40.0%) slightly less than half of the time. Two paramastoid processes (2/5, 40.0%) are observed in male inferior occipital bones and none are observed in females.

Cranial suture wormian bones are rare in these crania, noted only in the lambdoidal sutures. Cranial vault shape is typically *haus*-form, with a slight grooving of the

sagittal suture in half of the female crania. The frequency of parietal notch is greater in males (10/34 or 29.4%) than in females (2/19 or 10.5%). Accessory bones are rarely found at the parietal notch and the asterion. Relative to other Chamorro samples, the frequency of tympanic thickening is unusually high in this cranial series (42.5%), occurring with no apparent sex differences.

In the mandible, nonmetric variation includes multiple mandibular foramina and multiple mental foramina both of which are more common in males than females. None of the mandibles has a full rocker morphology, a Polynesian characteristic (Houghton, 1980), but the anterior rocker variation observed in four females is statistically significant. Chin morphology is more variable in males than in females, while the mandibular coronoid process is typically higher than the condyle in both sexes.

A high incidence of absence of the posterior condylar canal and precondylar tubercles, and tympanic thickening distinguish the Apurguan cranial remains from other Mariana samples (Pietrusewsky et al., 1992). The absence of statistical significance in the pattern of sex differences observed in these skull nonmetric traits suggests relatedness, but the effects of small sample size cannot be ruled out. Comparisons with other sizable, locally circumscribed skeletal samples are necessary to further illuminate these differences.

An additional epigenetic variation, or occupational indicator, of the posterior occipital bone (retromastoid process) was observed in two males (Burial 100 and Burial 101). These processes occur bilaterally, are knob-like, continuous with the occipital cortex, and appear symmetrical in size and shape. They are found at the terminus of the superior nuchal line just inferior to the asterion, and would be considered prominent (score of 3) following Heathcote et al. (1996). Although not scored systematically, an incidence can be approximated using the number of skulls with biasterionic measurement, as 2/15 or 13.3% of males, and 0/10 females. The etiology of the retromastoid processes is likely to involve an interplay of genetic, developmental, and physical influences (Hauser and De Stefano, 1989; Heathcote et al., 1996) and may be related to construction of the latte stone structures using huge blocks of limestone.

Dental morphology

Very few complete dentitions were found in the Apurguan series, so variation is summarized, by tooth, in 42 adult males and 32 adult females. In males, Tooth Summary (sum of cross-sectional areas calculated using the mean mesiodistal and mean buccal-lingual diameters divided by the number of tooth classes) is 1,259.5 and in females it is 1,236.9, indicating fairly large tooth size. Combining sexes, the Tooth Summary Figure, using the same method, is 1,272.6.

Summary of the dental nonmetric variation observed in the adult and adolescent permanent teeth (Table 3) shows two statistically significant sex differences. The maxillary incisors are typically shovel-shaped, and Carabelli's cusp, an accessory cusp on the lingual aspect of the maxillary molars, is noted in 14.4% of the maxillary molars. Betel-staining, a reddish-brown stain usually seen on the labial crown surfaces of the anterior teeth, is significantly more common in female teeth than in male teeth and was not observed in individuals less than 15 years of age. Failure of the third molar to form (agenesis) is common in both sexes. Extensions of the enamel into the neck region of the molar teeth occur in 5.1% of molars, and are significantly more frequent in female teeth (9.4%) than in male teeth (3.3%). A protostylid cusp, noted in one female molar, and peg-shaped teeth, noted only in males, are rare in this series.

Oral-dental pathology. The frequency of oral-dental pathology in Apurguan adult teeth, summarized in Table 4, falls within the range of other preagricultural communities (Lukacs, 1989). The correlation of these pathologies with each other, and their age-dependence (i.e. increasing with advancing age) requires careful consideration. The general observation that all dental pathologies are more common in female teeth/sockets might be attributed to an older age-at-death, so additional analyses were made, controlling for age in broad intervals (young adult, middle aged, and old).

Premortem tooth loss is slightly higher in females (7.4%) than in males (6.2%), with a

TABLE 2. Summary of non-metric variation recorded in adult and adolescent skulls

	Male		Female			Total	
Trait (variation)[1]	A/O	%	A/O	%	Test	A/O	%
Metopic suture							
present	0/17	0.0	0/9	0.0		0/26	0.0
Frontal grooves							
present	0/32	0.0	0/22	0.0		0/54	0.0
Supraorbital structure							
absent	2/30	6.7	3/19	15.8		5/49	10.2
single foramen	5/30	16.7	2/19	10.5		7/49	14.3
double foramen	2/30	6.7	0/19	0.0		2/49	4.1
single notch	18/30	60.0	14/19	73.7		32/49	65.3
notch and foramen	3/30	10.0	0/19	0.0		3/49	6.1
Spina trochlea							
present	1/18	5.6	0/6	0.0	ns	1/24	4.2
Infraorbital foramen							
single	10/12	83.3	5/5	100.0		15/17	88.2
double	2/12	16.7	0/5	0.0	ns	2/17	11.8
Zygofacial foramen							
absent	5/40	12.5	3/28	10.7	ns	8/68	11.8
Infraorbital suture							
present	1/7	14.3	2/4	50.0	ns	3/11	27.3
Subnasal morphology							
sharp	3/16	18.8	3/12	25.0		6/28	21.4
not sharp	13/16	81.3	9/12	75.0	ns	22/28	78.6
Marginal tubercle							
none	8/26	30.8	7/18	38.9		15/44	34.1
slight	7/26	26.9	11/18	61.1		18/44	40.9
moderate	9/26	34.6	0/18	0.0		9/44	20.5
marked	2/26	7.7	0/18	0.0		2/44	4.5
Palatine torus							
none	13/14	92.9	7/7	100.0		20/21	95.2
ridge	1/14	7.1	0/7	0.0	ns	1/21	4.8
Os japonicum							
present	0/21	0.0	0/9	0.0		0/30	0.0
Maxillary torus							
present	0/34	0.0	0/19	0.0		0/53	0.0
Ovale-spinosum							
abnormal	0/12	0.0	0/5	0.0		0/17	0.0
Ant. condylar canal							
single	13/21	61.9	7/10	70.0		20/31	64.5
bridge	8/21	38.1	3/10	30.0	ns	11/31	35.5
Post. condylar canal							
absent	6/13	46.2	2/7	28.6		8/20	40.0
single	7/13	53.8	5/7	71.4	ns	12/20	60.0
Precondylar process							
present	0/6	0.0	0/3	0.0		0/9	0.0
Ossified apical lig.							
slight	1/6	16.7	0/3	0.0	ns	1/9	11.1
Pharyngeal fossa							
present	0/6	0.0	0/2	0.0		0/8	0.0
Paramastoid process							
present	2/5	40.0	0/1	0.0	ns	2/6	33.3
Mastoid suture							
present	14/44	31.8	16/34	47.1	ns	30/78	38.5
Mastoid for. position							
none	0/34	0.0	2/24	8.3		2/58	3.4
temporal bone	27/34	79.4	16/24	66.7		43/58	74.1
occipital-mastoid suture	6/34	17.6	3/24	12.5		9/58	15.5
suture and temporal bone	1/34	2.9	3/24	12.5		4/58	6.9
Parietal foramen							
absent	17/37	45.9	8/20	40.0	ns	25/57	43.9
Coronal wormian							
present	0/30	0.0	0/18	0.0		0/48	0.0
Bregmatic bone							
present	0/18	0.0	0/11	0.0		0/29	0.0
Sagittal wormian							
present	0/15	0.0	0/9	0.0		0/24	0.0
Lambdoidal wormian							
present	8/31	25.8	3/19	15.8	ns	11/50	22.0

(Continued)

TABLE 2. (continued)

Trait (variation)[1]	Male A/O	Male %	Female A/O	Female %	Test	Total A/O	Total %
Os inca							
present	0/18	0.0	0/11	0.0		0/29	0.0
Vault form							
haus-form	12/13	92.3	7/8	87.5		19/21	90.5
round	1/13	7.7	0/8	0.0		1/21	4.8
hay-rick	0/13	0.0	1/8	12.5		1/21	4.8
Sagittal keeling							
none	13/15	86.7	5/10	50.0		18/25	72.0
slight	1/15	6.7	0/10	0.0		1/25	4.0
slight groove	1/15	6.7	5/10	50.0		6/25	24.0
Occiput form							
mound	3/21	14.3	3/15	20.0		6/36	16.7
mound and ridge	15/21	71.4	12/15	80.0		27/36	75.0
mound, ridge and inion	3/21	14.3	0/15	0.0		3/36	8.3
Sagittal bregma deflec.							
present	3/17	17.6	0/10	0.0	ns	3/27	11.1
Pterion							
H-form	2/2	100.0	2/2	100.0		4/4	100.0
Parietal notch							
present	10/34	29.4	2/19	10.5	ns	12/53	22.6
Parietal notch bone							
present	1/34	2.9	0/19	0.0	ns	1/53	1.9
Asterionic bone							
absent	2/41	4.9	1/22	4.5	ns	3/63	4.8
Tympanic thickening							
present	21/45	46.7	10/28	35.7	ns	31/73	42.5
Tympanic dehiscence							
present	2/43	4.7	2/31	6.5	ns	4/74	5.4
Tympanic marginal for.							
present	2/39	5.1	0/29	0.0	ns	2/68	2.9
Auditory exostoses							
present	0/46	0.0	0/35	0.0		0/81	0.0
Mandibular torus							
present	0/61	0.0	0/41	0.0		0/102	0.0
Mylohyoid bridge							
absent	51/52	98.1	31/32	96.9		82/84	97.6
distal bridge	1/52	1.9	1/32	3.1	ns	2/84	2.4
Mandibular foramen							
multiple	10/50	20.0	2/31	6.5	ns	12/81	14.8
Mental foramen							
multiple	7/62	11.3	3/40	7.5	ns	10/102	9.8
Rocker jaw							
none	29/29	100.0	14/18	77.8		43/47	91.5
anterior	0/29	0.0	4/18	22.2	**	4/47	8.5
Chin form							
median point	8/31	25.8	16/20	80.0		24/51	47.1
bilateral point	12/31	38.7	4/20	20.0		16/51	31.4
bilat pt and angled infer	10/31	32.3	0/20	0.0		10/51	19.6
med and bilat and angled	1/31	3.2	0/20	0.0		1/51	2.0
Ramus shape							
coronoid > condyle	44/45	97.8	26/28	92.9		70/73	95.9
coronoid = condyle	1/45	2.2	2/28	7.1	ns	3/73	4.1

[1] Right and left sides combined. Scored as present or absent, unless other variation is indicated. A = affected, O = observed in 34 males and 31 females. Statistical testing of sex differences at $\alpha = 0.10$ and 0.05, ns = not significant, * $P < 0.10$, ** $P < 0.05$.

low frequency (6.7%) overall. No statistical difference in tooth loss occurs in the young and old-aged adults, but loss is significantly greater in middle-aged males than females. Carious lesions, occurring equally in male and female teeth, are uncommon, likely because of a high frequency of betel-nut chewing, which has cariostatic effects (Howden, 1984), as well as a high rate of dental wear. Controlling for age, caries frequency is significantly greater in young adult male teeth (none in females) and old-aged male teeth. The presence of caries in young adult males and not females might suggest differential access to sticky or sweet foods. The overall frequency of dental abscessing is

TABLE 3. Non-metric variation in adult and adolescent permanent teeth

	Male		Female			?Sex		Total	
Dental variation[1]	A/O	%	A/O	%	Test	A/O	%	A/O	%
Shoveled max. incisors									
Absent	12/91	13.1	1/43	2.3	ns	7/58	12.1	20/192	10.4
Present[2]	79/91	86.8	42/43	97.7		51/58	87.9	172/192	89.6
Carabelli's cusp	18/149	12.1	9/91	9.9	ns	16/58	27.6	43/298	14.4
Betel-stained teeth	483/787	61.4	384/534	71.9	**	4/162	2.5	871/1483	58.7
Third molar agenesis	23/105	21.9	22/68	32.4	ns	0/8	0.0	45/181	24.9
Protostylid cusp	0/155	0.0	1/105	1.0	ns	0/52	0.0	1/312	0.3
Molar enamel extension	9/269	3.3	17/180	9.4	**	0/59	0.0	26/508	5.1
Peg-shaped teeth	2/821	0.2	0/580	0.0	ns	0/356	0.0	2/1757	0.1

[1] Right and left sides combined. Scored as present or absent. A = affected teeth/sockets, O = observed teeth/sockets in 42 males and 32 females. Statistical testing of sex differences at $\alpha = 0.10$ and 0.05, ns = not significant, * $P < 0.10$, ** $P < 0.05$.
[2] Slight, moderate and marked degrees.

also low (5.1%), though there are significantly more abscesses in female alveoli (8.0%). Controlling for age, abscesses are significantly more common in old-aged females than males.

The dental indicators of periodontal or gum disease include alveolar resorption, calculus and rolled rim. Moderate and marked degrees of alveolar resorption, scored by observing tooth root exposure, occur in more than a quarter of the tooth sockets observed (26.7%), with a slightly higher frequency in females. No statistically significant sex differences are noted in the young and middle-age categories, but old-age male alveoli have more resorption than comparable females. Although higher in females than males, rolled rim is uncommon, and exhibits no age-controlled sex differences. Moderate and marked levels of calculus are observed in 20.7% of the permanent teeth. Although not noted in the overall frequencies, male teeth have significantly more advanced calculus than female teeth in all three age categories.

Hypoplasia of the dental enamel (all degrees, in all tooth types) occurs equally in both sexes. When age is controlled however, female teeth have a significantly greater frequency of hypoplasia in the young and middle-aged categories, suggesting greater physiological insult in childhood than experienced by males. Moderate (dentin exposure) and/or marked (pulp exposure/wear to the roots) levels of tooth wear are noted in 25.5% of adult teeth, with a significantly higher frequency of advanced wear in female teeth. However, no statistically significant sex differences in attrition are noted when age is controlled.

The frequencies of adult dental pathologies are low in this sample, reflecting a preagricultural economy and the beneficial aspect of betel-nut chewing. Analyses by controlling for age suggest the sex differences in frequencies of dental pathologies are not related to the age distribution, since there are few significant differences in the "old age" category. Instead, sex differences

TABLE 4. Oral-dental pathology in Apurguan adult dentitions

	Male		Female			Total	
Dental pathology[1]	A/O	%	A/O	%	Test	A/O	%
Premortem tooth loss	56/909	6.2	47/639	7.4	ns	103/1548	6.7
Caries	22/772	2.8	11/512	2.1	ns	33/1284	2.6
Abscesses	23/702	3.3	36/451	8.0	**	59/1153	5.1
Alveolar resorption[2]	115/520	22.1	95/267	35.6	**	210/787	26.7
Rolled rim[2]	10/478	2.1	12/245	4.9	*	22/723	3.0
Calculus[2]	151/723	20.9	102/499	20.4	ns	253/1222	20.7
Hypoplasia[3]	68/330	20.6	62/247	25.1	ns	130/577	22.5
Attrition[2]	179/765	23.4	145/508	28.5	**	324/1273	25.5

[1] Right and left sides combined. A = affected teeth/sockets, O = observed teeth/sockets in 40 males and 31 females. Statistical testing of sex differences at $\alpha = 0.10$ and 0.05, ns = not significant, * $P < 0.10$, ** $P < 0.05$.
[2] Includes moderate and marked levels only.
[3] Includes all levels of hypoplasia and all tooth types.

TABLE 5. Deciduous dental pathology from Apurguan

	Maxilla						Mandible							
	Molars		Canine		Incisors		Molars		Canine		Incisors		Total	
Trait	A/O[1]	%	A/O[1]	%	A/O[1]	%	A/O[1]	%	A/O[1]	%	A/O[1]	%	A/O[1]	%
Hypoplasia[2]	0/69	0.0	0/30	0.0	0/31	0.0	0/72	0.0	0/31	0.0	0/50	0.0	0/283	0.0
Caries	6/65	9.2	4/27	14.8	8/38	21.1	1/65	1.5	0/25	0.0	1/34	2.9	20/254	7.9
Abscesses	0/9	0.0	0/6	0.0	0/8	0.0	0/52	0.0	0/16	0.0	0/15	0.0	0/106	0.0
Attrition														
None	13/65	20.0	2/29	6.9	9/35	25.7	26/71	36.6	5/28	17.9	8/42	19.0	63/270	23.3
Enamel	52/65	80.0	27/29	93.1	24/35	68.6	45/71	63.4	23/28	82.1	34/42	81.0	205/270	75.9
Dentin	0/65	0.0	0/29	0.0	2/35	5.7	0/71	0.0	0/28	0.0	0/42	0.0	2/270	0.7

[1] Right and left sides combined. A = affected tooth/sockets, O = observed tooth/sockets in 29 subadults ranging in age from <1 year to age 10.
[2] All degrees.

(e.g. more caries in young adult males than females) imply that there may be differential susceptibility to the defects, differential access to foodstuffs, differential physiological insults, and/or differential cultural behaviors (such as betel nut chewing) which impact dental health.

Deciduous dental pathology. Selected oral-dental pathology observed in the deciduous teeth of 29 subadults (Table 5) includes an absence of dental enamel hypoplasia and abscessing, and a caries frequency of 7.9%. Examination of the distribution of the caries in these teeth shows more carious lesions in the maxilla (13.8%) than in the mandible (1.6%), with a predilection for the maxillary canines and incisors. Horizontal carious lesions on the labial crown of these anterior teeth are often the result of preexisting hypoplasias, which are more susceptible to caries, and are then obscured by the enamel destruction (Hanson, 1990). No carious lesions are noted in the deciduous teeth prior to the age of 3 years. Dental attrition in the Apurguan deciduous teeth is predominantely of the enamel, with dentin exposure noted in the incisors by the age of 4 years.

Infracranial skeletal morphology

Infracranial indices, calculated from the mean measurements in 48 males and 32 females, document the typical Chamorro rounded humeral midshaft in both males and females (humeral diaphyseal index: 79.9, 77.6). The forearm is relatively long compared to the upper arm in males (radio-humeral index: 85.9) and medium (77.9) in females. The intermembral indices in both sexes reflect relatively short arms compared to leg length (males 65.6, females 69.5). The relationship of upper arm length to the length of the thigh (femur-humeral index) is also relatively short in both males (64.3) and females (70.4). A similar relationship (tibia-radial index) is found in the relative length of the lower arm compared to the lower leg length (males 67.2, females 68.2).

Lower leg length expressed as a proportion of thigh length (tibia-femur or crural index) is 82.2 in males and 80.4 in females. The upper femoral shaft is platymeric (84.1) in males and rounded in females (85.1), a finding consistent in Mariana Islands samples, while the femoral midshaft has a weak to medium pilastric index in both sexes (109.9, 111.4). The tibial shafts at the level of the nutrient foramen are typically triangular (males 70.7, females 72.7). The patella module is larger in males (36.5) than in females (33.9), reflecting sex differences in muscle mass and size. The lumbar vertebral index, comparing posterior heights to anterior heights, indicates a convex lower back in males (104.5), and a nearly flat or straight lower back in females (100.4). The range in stature for males, using Maori formulae (Houghton et al., 1975) on whole bones, is 167.8 ± 0.7 cm (5′6″) to 177.1 ± 0.5 cm (5′10″), with a mean of 172 cm (5′8″). Female stature ranges from 156.7 ± 2.7 cm (5′2″) to 168.4 ± 2.1 cm (5′6″), with an average of 163 cm (5′4″). These estimated statures indicate Apurguan males were tall and females were medium to tall in height, following Martin's classification (see Olivier, 1969).

TABLE 6. Non-metric variation in Apurguan infracranial skeletons

	Male		Female			Total (M + F + ?sex)	
Trait/variation[1]	A/O	%	A/O	%	Test	A/O	%
Sternal aperture							
present	0/3	0.0	0/3	0.0		0/7	0.0
Costoclavicular sulcus							
present	15/34	44.1	3/17	17.6	**	18/54	33.3
Supraclavicular foramen							
present	17/53	32.1	4/25	16.0	ns	23/82	28.0
Scapula humeral facet							
present	0/15	0.0	0/10	0.0		0/25	0.0
Suprascapular notch							
notch	2/2	100.0	3/3	100.0		5/5	100.0
Acromial shape							
rectangle	13/14	92.9	6/6	100.0	ns	19/20	95.0
irregular	1/14	17.1	0/6	0.0		1/20	5.0
Supratrochlear spur							
present	0/40	0.0	0/22	0.0		0/63	0.0
Septal aperture							
present	2/40	5.0	4/22	18.2	ns	8/63	12.3
Accessory sacral facets							
present	5/10	50.0	2/3	66.7	ns	7/13	53.8
Acetabular floor							
none	7/11	63.6	3/5	60.0	ns	10/16	62.5
pit	4/11	36.4	2/5	40.0		6/16	37.5
Fossa of Allen							
absent	4/8	50.0	0/3	0.0		4/11	36.4
porous	1/8	12.5	0/3	0.0		1/11	9.1
plaque	1/8	12.5	3/3	100.0		4/11	36.4
Poirier's facet	2/8	25.0	0/3	0.0		2/11	18.2
Third trochanter							
absent	19/25	76.0	4/18	22.2	**	24/44	54.5
ridge	6/25	24.0	14/18	77.8		20/44	45.5
Fovea capitis							
round	6/10	60.0	2/7	28.6		8/17	47.1
oval	4/10	40.0	4/7	57.1		8/17	47.1
irregular	0/10	0.0	1/7	14.3		1/17	5.9
Patella vastus facet							
present	27/43	62.8	14/22	63.6	ns	41/67	61.2
Patella vastus notch							
present	7/43	16.3	3/22	13.6	ns	10/67	14.9
Tibial squatting facet							
present	20/22	90.9	8/9	88.9	ns	29/32	90.6
Talar extension							
absent	1/49	2.0	2/32	6.3		3/84	3.6
medial	16/49	32.7	13/32	40.6		31/84	36.9
lateral	2/49	4.1	1/32	3.1		3/84	3.6
med and lateral	30/49	61.2	16/32	50.0		47/84	56.0
Talar squatting facet							
present	49/49	100.0	31/31	100.0		83/83	100.0
Calcaneal facet							
one	33/43	76.7	24/28	85.7	ns	59/73	80.8
two	10/43	23.3	4/28	14.3		14/73	19.2
Peroneal tubercle							
present	12/16	75.0	5/5	100.0	ns	17/21	81.0

[1] Present or absent unless other variation noted. A = affected, O = observed in 47 males and 29 females. Statistical testing of sex differences at $\alpha = 0.10$ and 0.05, ns = not significant, * $P < 0.10$, ** $P < 0.05$.

Infracranial nonmetric variation. Nonmetric variation systematically scored in the Apurguan adult and adolescent infracranial skeletons is summarized in Table 6. A costoclavicular sulcus, where the ligament of the same name attaches to the inferior medial border of the clavicle, is significantly more common in male clavicles (44.1%) than female clavicles (17.6%). This condition has been identified as an occupational stress marker resulting from strenuous use of the shoulder such as in canoe paddling (Houghton, 1980). A supraclavicular foramen which pierces the superior border of the clavicle is also present in more male clavicles (32.1%) than female clavicles (16.0%). The shape of

the acromial process is rectangular in the scapulae. Septal aperture, or perforation of the olecranon and coronoid fossae, is more common in female than male humeri.

Accessory facets on the internal surface of the iliac blade, to accommodate the sacrum, are not uncommon in this series (53.8% sides), with an equal presence in both sexes. The acetabular floor of the os coxae is either unmarked (62.5%) or has a pit (37.5%). The morphology of the anterior articular surface of the femoral head is more variable in males (porous, plaque and Poirier's facet) than in females (plaque). A raised ridge near the location of the third trochanter of the femur exhibits statistically significant sex differences: occurring more commonly in female bones (77.8%) than male bones (24.0%). The fovea capitis of the femur is either round (47.1%) or oval (47.1%) in these remains. Vastus facets, small depressions in the anterior surface of the superior-lateral angle of the patellae, and vastus notches, both reflecting the insertion of the vastus lateralis, occur equally in both male and female patellae. Tibial and talar squatting facets are common. Separation of the anterior and middle calcaneal facets into two discrete facets is found in more male calcanei than female bones. Peroneal tubercles on the lateral surface of the calcaneus are common.

Many of these nonmetric traits reflect stresses of activity (e.g. squatting facets) rather than differences in morphology (e.g. septal aperture) and so are likely to demonstrate sexual dimorphism (Finnegan, 1978). This is the case for greater prevalence of costoclavicular sulcus in males, while the greater prevalence of a ridge morphology at the femoral third trochanter in females is enigmatic. The overall absence of significant sex differences supports close genetic affinity as well as shared physical activities.

Vertebral nonmetric variation recorded in adults and adolescents is summarized in Table 7. The sample of vertebrae is skewed toward males. A constricted superior facet on the atlas is significantly more common in male than female vertebrae. An apical process of the dens occurs in 52.2% of the males as well as 27.3% of the females, a relatively high occurrence. The cervical foramen transversaria are typically single, and cervical vertebral spinous processes are divided in form between parallel, divergent and single. Laminal spurring is common in both male and female thoracic vertebrae. Spondylolysis in the lumbar vertebrae is found in eight male vertebrae (9.5%) and none of the female vertebrae; a difference which nears statistical significance ($\chi_c^2 = 2.647$, $P = 0.104$), and is suggestive of strenuous physical activity. Spina bifida, sacralization, lumbarization, and sacral hiatus are not found in this series. Again, the lack of statistically significant differences in the epigenetic traits of the vertebral elements may reflect close genetic affinities.

Paleopathology

Observations of signs of trauma, infection, and anomaly were made on the skeletal remains from Apurguan and are summarized in this section. Although the cause and method of death is very difficult to determine from skeletal remains, some inferences could be made in two burials from the Apurguan site. A female, buried with a newborn infant, suggests that both may have died of complications of childbirth (e.g. placenta previa or sepsis). A young adult male, Burial 57 (radiocarbon date (1 σ) AD 1460–1663), may have died of multiple spear wounds, with 10 beautifully crafted human bone spear points remaining in situ, apparently a ritualized slaying or execution (Fig. 3). This burial provided an opportunity to test our ability to distinguish perimortem trauma. Since the bone spear points were removed from the skeleton at excavation, we attempted to distinguish the perimortem injuries based upon discoloration and breakage of the skeletal elements alone. Only one of the 10 spear points produced damage to the skeleton which could be recognized as perimortem in nature. This incidence of a known traumatic cause of death demonstrates the difficulties inherent in distinguishing perimortem injuries without the additional evidence of the in situ weapon.

Trauma. Healed fractures are common in the Apurguan skeletal remains. Two individuals had multiple fractures: one person with a skull and rib fracture, and one with

TABLE 7. Non-metric variation and pathology in adult and adolescent vertebrae

	Male		Female			Total	
Trait/variation[1]	A/O	%	A/O	%	Test	A/O	%
C-1 superior facet bridge							
present	0/28	0.0	1/12	8.3	ns	1/40	2.5
C-1 atlas bridge							
present	1/26	3.8	0/10	0.0	ns	1/36	2.8
C-1 superior facet shape							
single	2/26	7.7	4/11	36.4	*	6/37	16.2
constricted	24/26	92.3	6/11	63.6		31/37	83.8
C-2 apical process							
present	12/23	52.2	3/11	27.3	ns	15/34	44.1
C1–C7 foramen transversaria							
single	73/77	94.8	27/32	84.4	ns	100/109	91.7
double	4/77	5.2	5/32	15.6		9/109	8.3
C2–C7 spinous process shape							
single	18/42	42.9	4/24	16.7		22/66	33.3
parallel	14/42	33.3	11/24	45.8		25/66	37.9
divergent	10/42	23.8	9/24	37.5		19/66	28.8
C1–C7 spina bifida							
present	0/71	0.0	0/34	0.0		0/105	0.0
T1–T6 laminal spurring							
present	100/114	87.7	48/59	81.4	ns	148/173	85.5
T7–T12 laminal spurring							
present	109/111	98.2	53/55	96.4	ns	162/166	97.6
T1–T12 spina bifida							
present	0/222	0.0	0/110	0.0		0/332	0.0
L1–L5 spina bifida							
present	0/87	0.0	0/46	0.0		0/133	0.0
L1–L5 laminal spurring							
present	82/110	74.5	34/46	73.9	ns	116/156	74.4
L1–L5 spondylolysis							
present	8/84	9.5	0/40	0.0	ns	8/124	6.5
L1–L5 mammillary for.							
present	1/93	1.1	0/36	0.0	ns	1/129	0.8
L1 transverse process							
normal	8/8	100.0	3/4	75.0	ns	11/12	91.7
facet	0/8	0.0	1/4	25.0		1/12	8.3
L5 sacralization							
present	0/11	0.0	0/7	0.0	ns	0/18	0.0
S1 lumbarization							
present	0/9	0.0	0/4	0.0	ns	0/13	0.0
Superior sacral hiatus							
absent	1/3	33.3	1/2	50.0	ns	2/5	40.0
S1	2/3	66.7	1/2	50.0		3/5	60.0
Inferior sacral hiatus							
S5	1/4	25.0	0/2	0.0		1/6	16.7
S5–S4	1/4	25.0	1/2	50.0		2/6	33.3
S4	0/4	0.0	1/2	50.0		1/6	16.7
S4–S3	2/4	50.0	0/2	0.0		2/6	33.3
Complete sacral hiatus							
present	0/7	0.0	0/4	0.0		0/11	0.0

[1] Right and left sides combined, present or absent unless other variation noted. A = affected, O = observed in 42 males and 23 females. Statistical testing of sex differences at $\alpha = 0.10$ and 0.05, ns = not significant, * $P < 0.10$, ** $P < 0.05$.

spondylolysis and an ulnar fracture. Three males had fractures of the outer table of the cranial vault: two small depressions in the parietal bone, and one circular defect of the frontal bone, for a frequency of 13.6% (3/22 cranial bones).

There are 10 fractures of the vertebral elements, including seven males with spondylolysis of eight lower lumbar vertebrae (see Table 7). Three males have healed fractures in the spine: a well-healed fracture of the lamina of a third cervical vertebra; a compression fracture of the 12th thoracic vertebral body, which is wedged-shaped, and has moderate osteoarthritis of the posterior articular facets; and a compression fracture

Fig. 3. Burial 57, a young adult male, in situ, with fatal wounds from human bone spear points. Note the point entering the left eye, and two points in the left thorax near the distal left humerus.

of the first and second lumbar vertebrae, with slight anterior compression, and complete fusion of the two bodies.

Healed fractures of the distal left ulna, called "parry" fractures after their most common cause, are present in two males (8.7% of ulnae), and healed fractures of an unassociated fourth metacarpal, and hand phalanges in three individuals, are also noted. In the lower limb, there is a single femoral fracture, in a female, which has healed but was complicated by extensive infection so that the bone is scarcely recognizable. A 6-year-old child has a small cortical bump on the anterior spine of the right tibia which may be a healing stress fracture.

There are no patterns of lesion shape or location in this series which would suggest the presence of warfare (Walker, 1989), but the predominance of fractures in males, the occurrence of two distal ulna fractures, and the death of at least one individual by spear points certainly suggest the presence of interpersonal violence in the society as well as some degree of physical risk.

Infection. Six males, two females, one adult of undetermined sex, and one child, ranging in age from 6 to 50 years, are affected with proliferative, appositional and destructive lesions which are consistent with treponemal disease (Steinbock, 1976; Ortner and Putschar, 1981). The tibia is the predominant site, with affliction of the fibula and ulna in a few cases. The characteristic pattern of occurrence of symmetrical periosteal apposition and osteitis are all suggestive of yaws (Fig. 4). Yaws, an infection caused by the *Treponema pallidum* spirochete, is a form of treponemal infection which is endemic in parts of Micronesia. The infection is generally acquired in children prior to puberty by contact with open lesions on the lower legs (Hackett, 1967). The initial evidence of the disease is a granulomatous sore followed in several months by a generalized skin rash. The late changes include lucent lesions in the bony cortex, florid periosteal bone formation, saber-shin, dactylitis, and, rarely, nasal destruction (Sengupta, 1985; Resnick and Niwayama, 1981:2196).

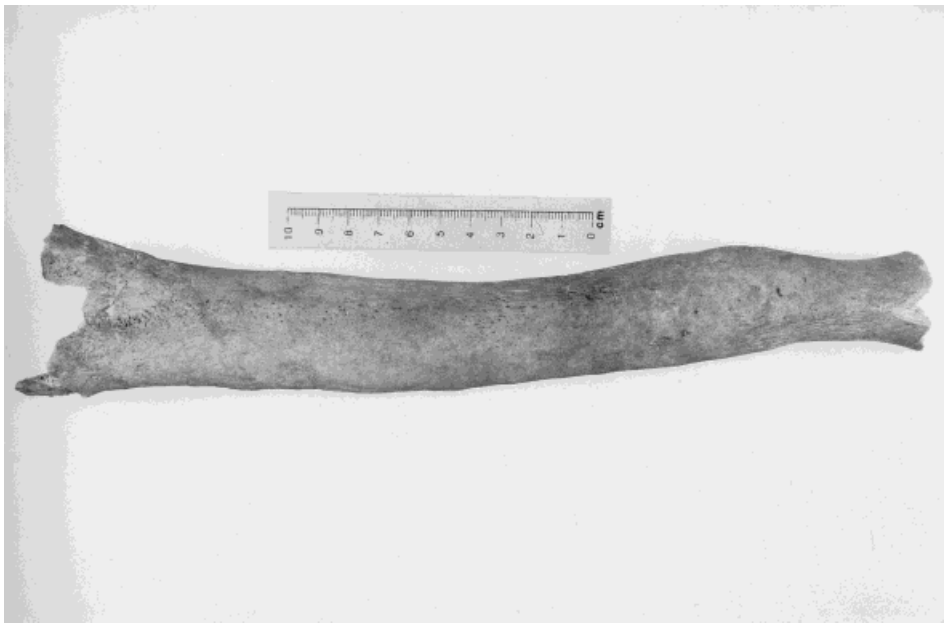

Fig. 4. Probable treponemal infection of the right tibial shaft. The ends of the bone have been lost to weathering.

In yaws, loss of the diaphyses of the phalanges with retention of the proximal and distal articular fragments is described (Hackett, 1967), which resembles changes in leprosy and some forms of arthritis, but, the distal phalanges are typically spared in yaws. In neural bone atrophy such as that found in leprosy, the bone absorption doesn't progress past the metatarsals and metacarpals, while in yaws, involvement of the long limb bones is primary. Osseous changes consistent with treponemal disease have been described in nearly all of the other Mariana Island skeletal samples examined thus far (see Pietrusewsky et al., this volume; Hanson, this volume).

Additional evidence for infection was also found. Two individuals, both males, have evidence of unilateral chronic mastoiditis (Loveland et al., 1990). There is pitting and a small smooth-walled opening of the suprameatal triangle, with active periosteal bone formation in one case. Radiographs of the temporal bones document underdevelopment of the mastoid sinuses and limited pneumatization. The occurrence of chronic childhood middle-ear infections may result in hearing loss in adulthood (Gregg and Gregg, 1987).

Six individuals have evidence of other nonspecific infections, in the form of proliferative reactive bone growth. Affected are the vertebral centra in two individuals, one possibly resulting from a herniated disc; another individual has periostitis of the auricular surface of the os coxae suggestive of infection, two instances of isolated nonspecific periostitis of the long limb bones, and two cases involving single ribs.

Hematopoietic disease. Two accepted indicators of iron deficiency anemia—cribra orbitalia, a porosis of the orbital roof, and porotic hyperostosis of the cranial vault—are uncommon in the Apurguan skeletal series (Palkovich, 1987; Steinbock, 1976; Stuart-Macadam, 1987, 1992). In the adults, cribra orbitalia was found in only one male orbit (1/30, 3.3%), and in no females (0/16), for a frequency in adult orbits of 2.2%. This represents one individual out of 17 males and 11 females (3.6%, 1/28). No cribra orbitalia was noted in the two subadult individuals with available orbits (0/3).

TABLE 8. Frequency of advanced osteoarthritis in the Apurguan adult appendicular skeletons

	Male		Female			Total	
Articular facets[1]	A/O	%	A/O	%	Test	A/O	%
Acromion	1/4	25.0	0/4	0.0	ns	1/8	12.5
Glenoid fossa	1/26	3.8	2/15	13.3	ns	3/41	7.3
Sternal clavicle	0/17	0.0	1/6	16.7	ns	1/23	4.3
Distal clavicle	2/22	9.1	0/7	0.0	ns	2/29	6.9
Humeral head	0/15	0.0	0/6	0.0		0/21	0.0
Capitulum	0/31	0.0	1/15	6.7	ns	1/46	2.2
Trochlea	0/29	0.0	1/16	6.3	ns	1/45	2.2
Radial head	0/33	0.0	2/16	12.5	ns	2/49	4.1
Distal radius	0/25	0.0	0/15	0.0		0/40	0.0
Proximal ulna	1/39	2.6	1/26	3.8	ns	2/65	3.1
Distal ulna	0/28	0.0	0/13	0.0		0/41	0.0
Carpals	2/72	2.8	4/44	9.1	ns	6/116	5.2
Metacarpals	1/65	1.5	2/38	5.3	ns	3/103	2.9
Sacro-iliac	1/12	8.3	2/6	33.3	ns	3/18	16.7
Acetabulum	0/18	0.0	0/11	0.0		0/29	0.0
Femoral head	0/12	0.0	0/5	0.0		0/17	0.0
Femoral condyles	2/18	11.2	2/12	16.7	ns	4/30	13.3
Patella	3/39	7.7	2/23	8.7	ns	5/62	8.1
Proximal tibia	1/18	5.6	0/8	0.0	ns	1/26	3.8
Distal tibia	1/24	4.2	0/10	0.0	ns	1/34	2.9
Proximal fibula	0/7	0.0	0/3	0.0		0/10	0.0
Distal fibula	2/17	11.8	0/9	0.0	ns	2/26	7.7
Calcaneus	1/46	2.2	3/27	11.1	ns	4/73	5.5
Talus	4/50	8.0	6/35	17.1	ns	10/85	11.8
Other tarsals	1/62	1.6	5/42	11.9	*	6/104	5.8
Metatarsals	1/66	1.5	5/39	12.8	**	6/105	5.7
Temporo-mandibular	2/27	7.4	1/31	3.2	ns	3/58	5.2
Occipital condyle	0/9	0.0	1/7	14.3	ns	1/16	6.3

[1] Right and left sides combined, moderate and marked levels of osteoarthritis. A = affected, O = observed articular facets in 45 males and 33 females. Statistical testing of sex differences at $\alpha = 0.10$ and 0.05, ns = not significant, * $P < 0.10$, ** $P < 0.05$.

Porotic hyperostosis of the cranial vault is more common, found in eight males and four females in this skeletal series. The ages range from 13 to 14 years to 50+ years. The ectocranial surface of the posterior parietal bones, superior occipital bone and the superior frontal bone are most often involved, with an "orange-peel" porosis described alternatively as coarse, or fine and healing (Mann and Murphy, 1990). The presence of this vault porosis is representative of a childhood porotic hyperostosis which is presumed to be the result of iron deficiency anemia related to nutritional disturbance and/or intestinal parasites (Stuart-Macadam, 1992).

Tumor. There is no evidence of primary or metastatic malignant tumors of the skeleton in the remains from Apurguan. Button osteomas are small, slow growing, dense tumors of bone which may be solitary or multiple and typically occur in the skull of middle-aged individuals (Ortner and Putschar, 1981; Zimmerman and Kelley, 1982). Five individuals, four males and one female, have these benign button osteomas on the frontal and parietal bones. The female (Burial 56A) has five osteomas. Using an estimate of cranial vaults available for examination based on those with length and breadth measurements (n = 22), the frequency of button osteomas in the cranial vaults is 13.6%. A single osteoma of the infracranial skeleton is noted along the axillary border of a right scapula (Burial 102A).

Osteoarthritis. Moderate degrees of appendicular osteoarthritis in the Apurguan adults are low, and severe osteoarthritis is rare (Table 8). Advanced osteoarthritis is more common in females than males, perhaps reflecting older age-at-death, though few of the differences are statistically significant. In females the most commonly affected regions are the sacroiliac joint, talus, sternal end of the clavicle and femoral condyles. In males, advanced osteoarthritis is most common on the acromial process of the scapula, femoral condyles and distal fibula. Marked osteoarthritis is rare, with single observa-

TABLE 9. Frequency of advanced degenerative changes in Apurguan adult vertebrae

	Male		Female			Total	
Pathology[1]	A/O	%	A/O	%	Test	A/O	%
Osteoarthritis of facets							
C-1 dens facet	2/20	10.0	2/10	20.0	ns	4/30	13.3
C-2 dens	0/25	0.0	2/16	12.5	ns	2/41	4.9
Cervical (C1–C7)	5/438	1.1	0/257	0.0	ns	5/695	0.7
Upper thoracic (T1–T6)	6/357	1.7	5/143	3.5	ns	11/500	2.2
Lower thoracic (T7–T12)	23/325	7.1	11/144	7.6	ns	34/469	7.2
Lumbar (L1–L5)	30/350	8.6	18/161	11.2	ns	48/511	9.4
Sacrum	0/17	0.0	0/8	0.0		0/25	0.0
Osteophytosis of centra							
Cervical (C2–C7)	2/151	1.3	0/87	0.0	ns	2/238	0.8
Upper thoracic (T1–T6)	0/126	0.0	0/38	0.0		0/164	0.0
Lower thoracic (T7–T12)	2/90	2.2	0/33	0.0	ns	2/123	1.6
Lumbar (L1–L5)	0/69	0.0	2/36	5.6	ns	2/105	1.9
Sacrum (S1)	0/8	0.0	0/3	0.0		0/11	0.0
Osteoporosis of centra							
Cervical (C2–C7)	6/80	7.5	3/51	5.9	ns	9/131	6.9
Upper thoracic (T1–T6)	0/63	0.0	0/20	0.0		0/83	0.0
Lower thoracic (T7–T12)	2/46	4.3	0/22	0.0	ns	2/68	2.9
Lumbar (L–L5)	1/39	2.6	2/18	11.1	ns	3/57	5.3
Sacrum (S1)	1/9	11.1	0/3	0.0	ns	1/12	8.3

[1] Moderate and marked levels only. Right and left sides combined, and upper and lower vertebral end-plates combined. A = affected, O = observed in 42 males and 30 females. Statistical testing of sex differences at $\alpha = 0.10$ and 0.05, ns = not significant, * $P < 0.10$, ** $P < 0.05$.

tions in a male sacroiliac joint, a male femoral condyle and a male proximal tibia; and no marked osteoarthritis in females. Statistically significant differences in osteoarthritis prevalence are found in the tarsals and metatarsals, where more advanced articular changes in females may reflect an older age-at-death, genetic predisposition, or differences in activity patterns.

Two cases of traumatic osteoarthritis are noted in this series. One middle-aged male (Burial 38) has a smooth-edged circular defect on the posterior right medial dome of the right talus which is 11 mm in diameter. This may be *osteochondritis dessicans*, a fragmentation and separation of the articular surface (Resnick, 1981a). An exostosis of the superior surface of the left first cuneiform is suggestive of a sprained foot (Burial 26).

Degenerative changes in Apurguan spinal columns were assessed in the vertebral bodies and the articular surfaces of the posterior elements (Table 9). Advanced osteoarthritis of the vertebral facets is greater in female first and second cervical vertebrae than in males, but total facet osteoarthritis is nearly equal (males 66/1532, 4.3%; females 38/739, 5.1%). Lipping of the vertebral bodies (osteophytosis) is uncommon in adults. Female lumbar vertebrae have more osteophytosis than male vertebrae, while osteoporosis of the vertebral end-plate is slightly more common in males than in females. Overall, moderate and marked degenerative vertebral changes are uncommon and slight sex differences are not statistically significant.

Gout. An interesting pattern of erosive bone loss was observed in four individuals, three males and one female. These lesions occur predominantely in the hands and feet and have common attributes: they are healed, there is very little reactive bone formation, there is erosion of the bone within the joint capsule but not on the articular surface although in some cases the articular surface appears "nibbled." There is an "undercutting" of the articular surface, much like the erosion of a stream bank, so that the articular surface overhangs the lytic defects. The shaft of the bone appears normal and the surrounding bones are typically normal in appearance, although the process may involve more than one bone in an individual. The lesions are generally asymmetric in the hand and symmetric in the foot and involve the proximal interphalangeal joint and the first metacarpal-phalangeal joint of the hand,

the midcarpal space (i.e. capitate, trapezium), and the head of the first metatarsal. While differential diagnosis includes gouty osteoarthritis, degenerative osteoarthritis, psoriatic osteoarthritis, and treponemal disease (Resnick, 1981b), similar observations made in other Guam samples have been proposed as evidence of gout (Rothschild and Heathcote, 1995).

Cultural alterations

Although dental modification, in the form of gouging or filing the labial crowns of the anterior teeth, has been described in other Mariana skeletal series (Ikehara and Douglas, 1993), no occurrences were found in the dentitions from Apurguan. There is a possible instance of deliberate ablation of the mandibular incisors in one of the adult males. All four of the incisors are lost, the alveolus is completely healed with a single root fragment retained, and there is no other tooth loss in the dentition. Review of the premortem tooth loss patterns in the sample revealed 9/19 (47.4%) individuals with loss of one or more of the maxillary or mandibular incisors with no other tooth loss. Deliberate removal of the incisors of both jaws is a cultural practice well documented in Hawaiian skeletal remains (Pietrusewsky and Douglas, 1993).

The prehistoric populations of the Mariana Islands lacked the medium-sized mammals, pig and dog, in their inventory of available natural resources. Skeletons of these animals provide much useful raw material for ceremonial, decorative and functional uses (e.g., dog tooth bracelets, boar tusk bracelets, awls, small bone tools). Evidently, in the absence of this raw material, there was a need to utilize human bone. The corpse was either left on the surface of the ground until such decomposition had taken place to make the bones readily available, or it was buried and disinterred at a later date (Hanson, 1988). The selected bones (most often long limb bones) were then recovered intact and used to fashion fishhooks and spear points, such as those found with Apurguan Burial 57.

Evidence of burial disturbance for acquisition of raw material is found in the pattern of missing skeletal elements, bones with cut marks, as well as the presence of articulated remains no longer in correct anatomical position. Fifteen individual burials, ten males (66.7%) and five females (33.3%), have evidence of prehistoric disturbance for the removal of skeletal elements, or burial with specific skeletal elements withheld (Table 10). The femur, tibia and fibula, followed by the humerus and the skull, are the most commonly selected elements, in that order of frequency. Of the seven individuals with missing humeri, five (71.4%) are missing the left humerus only. There are no instances of "bone debitage" or fragments of human bone, suggestive of breakage or cutting of the bone into tools.

Using the number of burial features with "primary" and "disturbed primary" archaeological provenience designations (n = 73), the incidence of deliberate disturbance is 20.5%, a frequency consistent with other Mariana Island sites, e.g., Hanson (1988) noted 26.7% (4/15) of the primary interments in a sample from Rota were disturbed and missing elements. In the skeletal sample from Afetna, Saipan (Tayles and Roy, 1985), one-quarter of the lower legs (5/20) had been removed, one individual was missing the forearms, and one burial was missing the skull and upper limbs.

At least three individuals interred in the Apurguan site have associated cranial or infracranial remains of other individuals, including an isolated three-skull cache. Other remains are disrupted, such as Burial 49, a moderately complete skeleton of a 6–8-year-old child, found with two articulated feet on top of the skull and the articulated lower limbs of another individual nearby. These associations, and movements of bones and individuals, demonstrate a complicated mortuary system which is just beginning to be illuminated, as increasing numbers of burial areas are excavated under controlled conditions.

SUMMARY AND CONCLUSION

One hundred fifty-two Latte Period human skeletal remains from Apurguan, Agana Beach, Guam, provide one of the most comprehensive views of the precontact Chamorro people currently available. Although the remains have been reinterred near the

TABLE 10. Burial disturbance for bone acquisition at Apurguan

Burial number	Sex	Age-at-death (in years)	Elements missing	
			Side	Bone
17	F	18–21	Bilateral	Femora, tibiae, fibulae
31	F	30–35	Bilateral	Femora, tibiae
			Right	Fibula
35	F	35–40	Bilateral	Tibiae, fibulae
102A	F	40–50	Bilateral	Femora, tibiae, fibulae
116	F	50+	Right	Humerus
			Bilateral	Femora, tibiae, fibulae
4	M	30–35	Left	Humerus
25	M	Middle age	Bilateral	Femora, tibiae, fibulae
45	M	50–60	Left	Femur
			Bilateral	Humeri, tibiae, fibulae
48	M	25–30	Left	Humerus
			Bilateral	Femora, radii, ulnae
62A	M	Young adult		Skull
			Left	Humerus
			Bilateral	Femora
97	M	16–17	Left	Humerus, femur
			Bilateral	Tibiae, fibulae, feet
99	M	Middle age		Skull
			Bilateral	Femora, tibiae, fibulae
100	M	40–45	Bilateral	Femora, tibiae, fibulae
101	M	30–40	Left	Humerus
			Bilateral	Femora, tibiae, fibulae
112	M	35–40	Bilateral	Femora, tibiae, fibulae

original village, the observations made and data collected will serve to define the ancient Chamorro people for future generations. Skeletal completeness and preservation are generally fair, primarily due to taphonomic processes, including both recent and prehistoric disturbances. Many of the burials had been disturbed postdepositionally for cultural purposes such as acquisition of raw material or keepsakes, with the skull, humerus, femur and tibia most commonly absent.

The representation of both sexes and most ages in the Apurguan sample is indicative of a long-term cemetery population. The demographic profile includes 51 subadults (33.6%) and 101 adults (66.4%). The sex ratio (53:43) demonstrates an underrepresentation of females, possibly related to differential burial practices. Adults, especially females, were long lived, with a mean age-at-death of 43.5 years. A high percentage of the subadult deaths occur between 2 and 9 years of age, perhaps resulting from nutritional, parasitic or disease stress. Analysis of juvenile mortality suggests the population was slowly increasing.

The Asian heritage of the Chamorro is demonstrated by skull indices which describe a medium cranial shape with a high vault, medium orbital and facial proportions, and narrow nasal aperture. Male mandibles are short and broad, while female mandibles are medium in shape. The teeth are moderately large in size, and maxillary incisors are typically shovel-shaped, varying in degree from slight to moderate. Influenced by the practice of betel-nut chewing as well as the subsistence economy, oral-dental health is good. Abscesses, advanced alveolar resorption and dental attrition are significantly more common in female teeth than male teeth, perhaps reflecting differential cultural practices such as betel-nut chewing or differential access to food resources.

Male statures are tall, with a mean of 171.1 cm, and female statures (mean = 162.0 cm) range from medium to tall. Limb proportions include relatively long forearms, and short arm lengths relative to leg lengths. Infracranial nonmetric variation typical of Chamorro samples exhibits few statistically significant sex differences, and includes evidence of active use of the shoulders in males, robust muscle attachments and squatting facets in both sexes.

Paleopathological observations noted in these skeletal remains include a preponderance of fractures in males: three skull fractures, three vertebral fractures, spondyloly-

sis in seven individuals, and two distal ulna fractures. A single complicated fracture of the femur is observed in a female. Periosteal appositional bone deposition in the ulna, femur, tibia, fibula and tarsal skeletal elements, consistent with treponemal disease (yaws), is described in 10 individuals. Chronic ear infection is suggested in two males. Osteoarthritis of the appendicular and vertebral skeleton is typically slight, with small differences in the sexes only in the site of occurrence. No malignant tumors are found in these remains and evidence of anemia is rare. Unusual observations include the possible execution death of a young adult male found with multiple bone spear points in situ in the skull and torso, and an erosive phenomenon of the bones of the hands and feet in several older males which may represent gouty arthritis.

The relatively large size of the present skeletal series, combined with the detailed, systematic recording of skeletal biological features, provides an important database for assessing the paleodemography, health and biological origins of the prehistoric inhabitants of the Mariana Islands. The paucity of statistically significant sex differences in skull, dental, and infracranial nonmetric variation suggests close genetic affinity, while significant sex differences in dental pathology may reflect differential cultural behaviors and/or resource access. Continued research and further comparisons both within and among the Chamorro skeletal series are necessary to illuminate the possible causes of these differences.

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